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(Article begins on next page)

Handsewn Semiclosed Single-Layer Jejunocecal Side-To-Side Anastomosis in the Horse

Marco Gandini¹, Med Vet, PhD

¹Faculty of Veterinary Medicine, University of Turin, Grugliasco, Italy

Corresponding Author

Marco Gandini, MedVetClinica Veterinaria
Pegaso, Strada Paverano 81, Rivoli (TO),
Italy
E-mail: mcgandini@hotmail.com

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Objective: To report a technique for semiclosed 1-layer side-to-side jejunocecal anastomosis in horses.

Study Design: Experimental study and clinical reports.

Sample Population: Part 1—In vitro: Intestinal specimens from 24 horses collected immediately after death at an abattoir. Part 2—Clinical cases: 10 horses with clinical signs of colic requiring jejunocecostomy.

Methods: Mean time to perform twelve 2-layer handsewn (HS2L) and 12 semiclosed 1-layer modified handsewn (SC) jejunocecal anastomoses was compared. Mean bursting pressures of anastomoses measured with a modified tank inflation test were compared. The SC technique was used in 10 horses that required jejunocecal anastomosis with and without resection (complete or incomplete ileocecal bypass).

Results: The SC technique was significantly quicker to perform than HS2L technique. Clinically, the technique appeared safe with a major complication, associated with obstruction from kinking of the anastomosis, occurring in 1 horse.

Conclusions: The SC technique was easy to perform with very little mucosal exposure in comparison to the HS2L technique, and was safe and effective in restoring intestinal continuity in clinical cases.

Clinical Relevance: The SC technique should be considered for jejunocecostomy in horses because it reduces anastomosis time and mucosal exposure compared with other techniques.

Handsewn and stapled jejunocecostomy techniques have been evaluated¹ for incomplete cecal bypass or jejunocecal or ileocecal anastomosis and until recently were considered better for establishing intestinal continuity after partial ileal resection than ileoileal or jejunoileal anastomosis.² Handsewn techniques have been described for side-to-side and end-to-side anastomosis,³ whereas intestinal staplers have been used for side-to-side jejuno(ileo)cecostomy.³

Stapled techniques are associated with less bowel manipulation and contamination, and decreased surgical time if staple lines are not oversewn. In some cases stapled anastomoses carry a higher risk of complications, like adhesions, stricture formation, hemorrhage, and leakage.³

Our purpose is to describe a technique for jejunocecal side-to-side anastomosis with minimal mucosal exposure, bowel manipulation, and reduced surgical time. We compared functional characteristics of this technique with those of a handsewn 2-layer (HS2L) jejunocecal anastomosis. To test this we constructed jejunocecal anastomosis in fresh intestinal segments and measured construction time, bursting pressure and evaluated failure mode. The technique

was then evaluated in 10 horses that required jejunocecal anastomosis.

MATERIAL AND METHODS

Part 1—In vitro Study

Intestinal specimens consisting of distal jejunum, ileum, ileocecal valve, and cecum from 24 horses were collected at an abattoir, washed, and transported at room temperature in lactated Ringer solution (LRS).^{4,5} Twelve segments were used to create a 2-layer inverting jejunocecal anastomoses and 12 to create semiclosed 1-layer inverting jejunocecal anastomoses. All anastomoses were created within 4 hours of death and then stored in LRS until mechanical testing was performed within an hour.

Surgical Technique

Semiclosed 1-Layer Jejunocecostomy (SC). The jejunum was transected at least 1 m proximal to the ileum and the edges of the proximal (jejunal) and distal (ileal) stump inverted with a Parker–Kerr suture pattern (using 2-0 polyglactin 910) over a crushing Hartmann's intestinal clamp.

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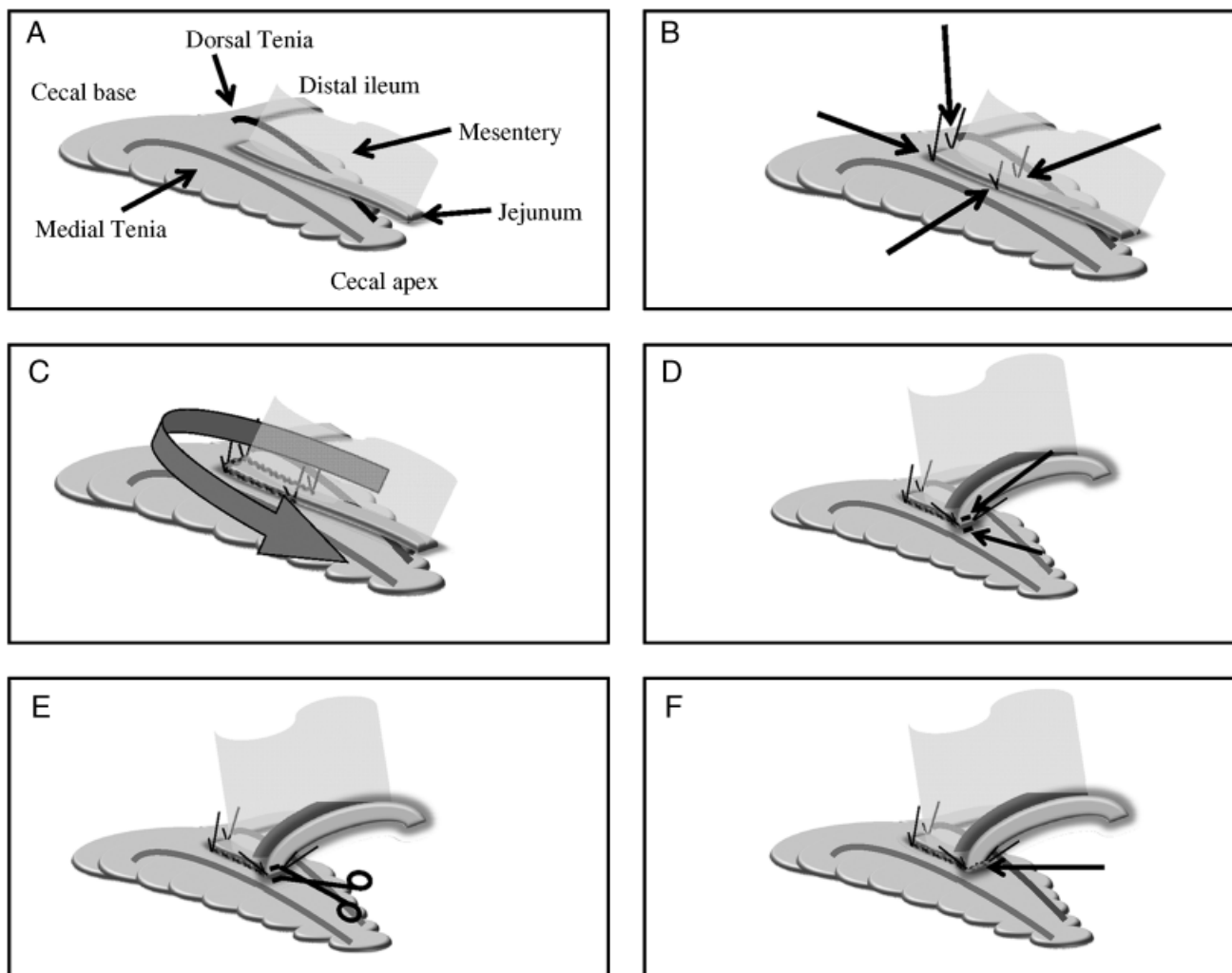


Figure 1 Construction of a handsewn semiclosed 1-layer jejunocostomy. (A) Initial position of the jejunal stump on the cecal body; (B) position of 4 stay sutures, 2 on each side of the antimesenteric border (arrows); (C) continuous Lembert suture running from the proximal stay suture to the distal one on the far side then running across the distal extremity of the stump and back to the proximal stay suture on the near side (arrows); (D) opening of lumens with 2 parallel stab incisions (arrows); (E) insertion of 2 crushing bowel clamps and creation of the stoma with scissors; and (F) closure of the fourth side of the anastomosis with a continuous suture between the 2 proximal stay sutures (arrows).

The jejunal stump was then placed with its antimesenteric side on the body of the cecum between the dorsal and medial teniae. To standardize stoma position for different cecal sizes, we divided the cecal length in thirds and placed the stoma in the distal part of the proximal third, which was ~15–20 cm from the ileocecal valve towards the cecal apex (Fig 1A) and fixed the jejunum with 4 stay sutures (Fig 1B). The distance between the 2 proximal stay sutures and the distal ones was 14 cm (standardized with a ruler). The assistant surgeon then placed tension on 2 of the stay sutures on the same side to align the 2 segments of bowel.

A Lembert suture pattern (2-0 polyglactin 910) comprising serosa, muscularis, and submucosa of the 2 bowel segments was started at the stay suture at the proximal aspect of the terminal jejunum and continued distally (toward the cecal base) to the ipsilateral stay suture. At this level the su-

ture was tied before being continued to the distal stay suture on the opposite site of the jejunal stump where it was tied again. The jejunal stump was reversed and another Lembert suture performed on the opposite site towards the proximal stay suture where it was tied again (Fig 1C).

The 2 proximal stay sutures were then used to lift the 2 bowel segments up to the level where the jejunal stump was nearly vertical. To enter the intestinal lumen a 25–30 mm full-thickness incision with a # 10 scalpel blade was performed on the facing sides of the cecum and jejunum (Fig 1D). Two Hartmann crushing bowel clamps were then placed into the enterotomies about 1–1.5 cm apart, taking care to not cross the suture lines. Lister scissors (GIMA spa, Gessate [MI], Italy) were then introduced between the 2 bowel clamps and the 2 adjacent bowel walls cut, being careful to not to cross the distal suture line (Fig 1E). To

avoid cutting this end of the stoma this part of the suture was held between the surgeon's fingers. Once the stoma was created the anastomosis was completed by apposing the free ends of the cecum and jejunum by continuing the previously interrupted Lembert suture (Fig 1F).

Two-Layer Anastomosis (HS2L). The jejunal stump was isolated with a crushing bowel clamp, resected and inverted with a Parker–Kerr suture. The stump was then apposed on the cecal body and a serosubmucosal continuous suture (2-0 polyglactin 910) was used to connect the 2 segments for a standardized length of 14 cm. The suture was tied at the end but not cut. The serosa and muscularis of the jejunal stump and of the cecal body were cut for a length of 13 cm, leaving the mucosa intact. A continuous suture (2-0 polyglactin 910) comprising mucosa and submucosa of both intestinal segments was placed alongside of the 1st one and tied at the end of the incision. The mucosa of the 2 segments was then incised creating the stoma. The mucosal suture was then completed on the other side of the stoma. The seromuscular suture was completed with the 1st strand.⁶

Leak Testing

After completion, each anastomosis was tested for leakage by injecting 100 mL water into the proximal jejunum and gently milking it through the anastomosis to mimic transit of intestinal content.

Construction Time

Time (minutes) for anastomosis construction was defined as the time between positioning of the crushing clamp on the jejunal stump and placement of the final suture.

Bursting Pressure

Each anastomosis was tested for leakage by air filling and subsequent submersion in a water tank to test for bursting strength using a gas inflation tank test.^{4,5} After completion of the anastomosis, the ileocecal valve was closed by application of a plastic tie over the ileal remnant. The jejunum was transected and ligated ~30 cm proximal to the anasto-

mosis. A metal cannula connected to a compressed air tank was inserted into the jejunal lumen and a similar cannula inserted in the cecum distal to the anastomosis. The cecal cannula was connected to a calibrated mercury sphygmomanometer. Air-tight sealing of the cannula insertion was assured by placement of a plastic tie over the intestinal wall. Each specimen was submerged in water and inflated with air at 1 L/min until gas leaked from the bowel.^{4,5} Luminal pressures were continuously measured and recorded by digital camera. Review of the recordings allowed evaluation of the exact peak pressure at specimen failure. Failure was confirmed by detection of gas bubbles leaking from the submerged intestine and by observing a decline in the luminal pressure. In some cases complete bursting of the anastomosis or intestinal wall occurred, causing a sudden drop of measured pressure.

Statistical Analysis

Mean \pm SEM construction time (paired Student's t-test Welch corrected) and bursting pressure (Wilcoxon's matched pair test) were compared for each anastomosis type using software (Graphpad InStat[®] version 3.05 for Windows 95/NT, GraphPad Software, San Diego, CA; <http://www.graphpad.com>) with significance set at $P \leq .05$.

Part 2—Clinical Cases

Ten horses (aged, 9–23 years; weight, 400–560 kg) that required treatment to resolve ileal or ileocecal valve obstruction had an SC anastomosis. Horses with pathology of the ileum and/or jejunum that precluded use of an end-to-end ileoileal or jejunoileal anastomosis had a complete ileocecal bypass (4 horses) and horses where only the ileocecal valve was affected had an incomplete bypass performed (6 horses; Table 1).

Surgical technique for SC was as described for the in vitro study, except for incomplete ileocecal bypass where the jejunum was not transected and closed with the Parker–Kerr suture, but simply apposed on the cecal body wall (Fig 2). Furthermore, a stay suture was applied proximally to the anastomotic site between the cecum and jejunum to avoid kinking of the anastomosis and obstruction. At completion, each anastomosis was tested for leakage

Table 1 Signalment, Surgical Details, and Complications of 10 Horses that had Handsewn Semiclosed Single Layer Jejunocecostomy

Horse	Breed	Gender	Age	Weight (kg)	Diagnosis	Strangulation	Anastomosis	Complications
1	TB	Male	9	450	Inguinal hernia	Yes	Complete bypass	POI—Wound infection
2	Selle Francaise	Female	15	400	Ileal impaction	No	Incomplete bypass	—
3	Standardbred	Gelding	12	560	Ileal impaction	No	Incomplete bypass	—
4	Mixed	Gelding	21	520	Pedunculated lipoma	Yes	Complete bypass	Wound infection
5	Standardbred	Female	10	515	Ileal impaction	No	Incomplete bypass	—
6	TB	Female	23	480	Pedunculated lipoma	Yes	Complete bypass	POI—relaparotomy
7	Mixed	Female	17	450	Ileal impaction	No	Incomplete bypass	POI
8	Selle Francaise	Gelding	10	560	Ileal impaction	No	Incomplete bypass	Wound infection
9	German Warmblood	Female	12	500	Ileal impaction	No	Incomplete bypass	Wound infection
10	Selle Francaise	Female	10	550	Epiploic foramen entrapment	Yes	Complete bypass	—

POI, postoperative ileus.

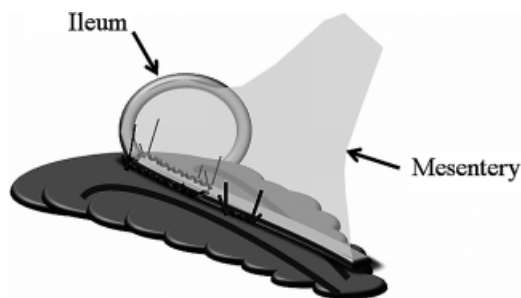


Figure 2 Position of the bowel segments in incomplete bypass.

and function by milking of intestinal content from the jejunum. The intestine was then repositioned in the abdomen before celiotomy closure.

Horses were administered intravenous (IV) lidocaine for 24 hours postoperatively (1.3 mg/kg as a bolus, followed by 0.05 mg/kg/min constant rate infusion) and LRS IV for 36–72 hours depending on the occurrence and duration of postoperative ileus (presence of > 2 L of gastric reflux on nasogastric intubation every 4 hours). Intramuscular procaine penicillin (8 mg/kg) and dihydrostreptomycin (8 mg/kg) were administered for 5 days and flunixin meglumine 3 times daily for 3 days at a decreasing dose (1.1, 0.5, 0.25 mg/kg IV). Complications (postoperative ileus, incisional infection, colic) and outcome were recorded.

RESULTS

Part 1—In vitro Study

Both anastomosis types had similar external appearance and none leaked when tested. Mean (\pm SEM) construction time for HS2L (29.23 ± 0.68 minutes) was significantly longer than for SC (12.33 ± 0.35 minutes; $P < .001$). All anastomoses were tested to failure with air and failed at eh anastomosis; 5 HS2L anastomoses failed suddenly with an abrupt decrease in air pressure, whereas all other constructs failed with detection of an air leak characterized by a mild decrease in pressure.

Mean (\pm SEM) bursting pressure for HS2L (164.58 ± 3.45 mmHg) was significantly higher than for SC (119.43 ± 10.22 mmHg; $P < .0008$).

Part 2: Clinical Cases

During surgery no leakage from the anastomotic site was detected after completion. Two cases (1 complete, 1 incomplete bypass) developed postoperative ileus that resolved within 72 hours. A 3rd horse (complete bypass) developed ileus 8 days postoperatively and was reoperated on the 9th day. Kinking of the anastomosis because of failure of the proximal stay suture was identified and repaired; the anastomosis was patent and functional and no further complications occurred.

Four horses developed mild incisional infection, characterized by moderate exudates that resolved before

hospital discharge. Horses were discharged 10–23 days postoperatively and at 6-month follow-up, no further complications or signs of colic were reported.

DISCUSSION

We found that a side-to-side jejunocecal anastomosis could be created using a semiclosed technique more rapidly than a HS2L anastomosis, but with lower bursting strength. However, the recorded bursting pressures (> 100 mmHg) for both anastomosis types were higher than intraluminal pressures (< 15 mmHg) recorded in horses with bowel distention from strangulating obstruction.⁷

Jejunocecostomy carries a higher risk of complications than jejunojejunostomy^{8,9} Handsewn techniques are technically demanding and take longer.³ Stapled jejunocecal anastomosis is an efficient time-saving method associated with less manipulation, contamination, and less operative time but if not oversewn has a higher risk of complications.³ The cutting thread technique, either with suture wire¹⁰ or by diathermy¹¹ reportedly reduces contamination in side-to-side anastomoses but is time-consuming.³ The SC technique combines the features of a stapled anastomosis with the low cost of a handsewn technique.

We found that SC anastomosis time was significantly reduced when compared to the 2-layer handsewn technique. This can be attributed to the reduced suturing time and to the simplicity of the SC technique which does not require double incisions to create the stoma and reduces the risk of contamination of the anastomotic site with luminal content.

None of the anastomoses leaked immediately after completion either in vitro or in vivo. All in vitro anastomoses resisted pressures > 80 mmHg. Bursting pressure is often used to compare different anastomotic techniques both acutely and during healing.^{4,5,12–19} In our experience, cecal distension is rarely a complication of jejunocecostomy and so it would be rare that such an anastomosis would be stressed by intraluminal pressure. In our study, failure always occurred at the anastomotic site and resulted from distortion of the suture line caused by considerable compliance and distention of the cecal wall. All anastomoses resisted pressures well over those reported for side-to-side jejunojejunal anastomosis performed with intestinal staplers.¹²

The bursting pressure of the anastomosis performed with the SC technique is significantly lower than for the 2-layer technique, although effectiveness of the 1-layer method has already been proven in studies of end-to-end anastomosis in horses.^{19,20} Particular care must be taken to place suture bites into the submucosa, and failure to do so was the primary cause of anastomosis failure in the in vitro study. Nevertheless the 1-layer technique resulted in a water-proof closure of the anastomosis and led to a successful outcome in clinical cases. The characteristics of the semiclosed technique described here, allowing manipulation of the 2 bowel segments with little exposure of the

mucosa, can be rapidly performed and could prove clinically useful. Special care should be taken when inserting the Lister scissors and cutting the 2 intestinal walls not to damage the suture lines.

Hemorrhage from the anastomotic site could be problematic,²¹ but was prevented by use of crushing forceps before stoma creation. With our technique the alignment of intestinal layers (serosa to serosa) is similar to that achieved with other methods like staplers or Compression Anastomotic Devices (Nitinol Rings) that have been demonstrated to provide a fully functional anastomosis.²²

Clinically, the SC technique was efficient and easy to perform. No clinically consequential hemorrhage from the anastomosis occurred and the only anastomosis-related complication was caused by disruption of the proximal stay suture. Minimum follow of 6 months revealed that all horses were alive and had no further episodes of colic. Additional studies need to be performed to identify potential chronic complications of the SC technique.

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